WBC-INCO.NET

Transport Research Priorities for Croatia 2009 - 2013

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1. Purpose of the national background report and methodology

This research has been performed within the project Western Balkan Countries INCO-NET that is aimed at enhancing integration of the so-called Western Balkan countries (WBC) in the European Research Area within FP7 for Research and Technological Development.

This project will last from 2008 to 2011, supporting the Steering Platform on Research for the Western Balkan countries in the facilitation of interaction between the Western Balkan countries, the EU Member States, states associated to the Framework Programmes for RTD and the European Commission. The main task is to help defining the areas of mutual collaboration, defining regional and national priorities coherent with European research agenda, as well as WB transport research communities.

The core objectives of WBC-INCO.NET are:

- to support the bi-regional dialogue on science and technology (S&T) by benefiting from and interacting with the Steering Platform on Research for the Western Balkan countries which was launched under the Austrian EU Presidency in 2006
- to identify RTD potentials and priorities for take-up in FP7 and other European programmes in a transparent and methodologically sound way
- to enhance participation of researchers from the region in European projects of mutual interest and benefit by implementing capacity building measures on a structural and individual level and by accompanying networking activities[1].

The activities peformed withing this project in order to achive the aforementioned objectives are:

- definition of thematic regional S&T priorities, analysis of opportunities to access infrastructure, barriers to cooperation and cooperation patterns, organisation of training workshops and learning groups (for example on research management, financial auditing and S&T indicators), in addition to brokerage events and awareness raising sessions,
- support to National Contact Points and Research Information Systems
- publishing of regular newsletters, a journal and the web-based information portal www.wbc-inco.net[2]

In this research, the source of information have been various public domain documents, mostly those available on official webpages of governmental institutions, public bodies,

[1] http://www.wbc-inco.net/about/index_en.html
[2] http://www.wbc-inco.net/about/index_en.html

research institutions, universities and private /public companies in the field of transport. In addition, information has been provided directly in contact with researchers within different areas of transport research. Through the analysis of public domain information, it was possible to get the objective picture of the sector, without subjectivity that is mostly connected with personal opinion of the participant. Some statistical data have been provided by the governmental services in Croatia and appropriate bodies of EC Directorates (DG-TRAN in particular).

Mr Ivica Smojver is an Associate Professor, Head of Chair of Aerodynamics at the Department of Aeronautical Engineering, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb. At the moment he is the project leader of one scientific and one technological project financed by the Ministry of Science, Education and Sports (MSES) in the field of numerical modelling of composite structures, as well as scientific participant in one FP6 Marrie Currie project. In addition, he is a National Representative in the FP7 Programme Committee (Transport) and in the FP7 Clean Sky JTI.

2. The Transport S&T system in Croatia

2.1 The Croatia and Transport policy framework

2.1.1 The overall Transport policy framework

The favourable geostrategic and transport position of Republic of Croatia is geographically defined as Middle-European and Mediterranean country, bridge in connecting Western and Middle Europe with Black Sea area, as well Eastern Europe and Baltic with Mediterranean.

According to the National classification of activities, transport includes the following activities of goods transportation and storage, as well as communications:

- regular and unordinary passenger and goods transport using railways, roads, water, air or pipelines
- supporting activities at terminals and parking stations, resupply of goods, storage etc.
- postal services and telecommunications
- renting of transportation means and equipment

However, taking into account the division of areas within FP7, pipelines, postal services and telecommunications are not included in the transport sector, and thus excluded from this report.

The transportation sector makes 8.1 % of GDB and 7.1 % of total employees (data for 2001, source Central Bureau of Statistics - CBS). National strategy on the transport

development is based on the need to satisfy total transport requirement, maritime and touristic orientation of Croatia, strategy of Croatian urban areas development and efforts to be integrated into the European transport sector.

EU is the most important trading partner to Croatia, and there is a steady increase in the EU-Croatia trade since the opening of the EU market under the Autonomous Trade Measures in 2000 and the trade provisions of the Stabilization and Association Agreement in 2002. In 2007, EU-imports from Croatia totalled €4.9 billion (14% of GDP) while EU exports to Croatia reached €13.2 billion (38% of GDP). The main source of export revenues are primarily composed of industrial goods (62.8%), including principally machinery (18%), textiles products (8.2%), transport equipment (5.1%) and chemical products (8.6%). The Croatian imports from the EU in 2007 were mainly industrial goods (72.7%) including machinery (16.2%), transport equipment (13.6% - of which 10.2% cars and trucks), chemical products (12%) and textile products (5%). In 2007, the EU was by far Croatia's main trading partner (67% of external trade). In 2007, EU foreign direct investment totalled €3.57 billion (9.5% of Croatia's GDP) with almost all inflow coming from EU 27 (99%). In the year 2004, the gross domestic product *per capita* was measured as standard purchasing power, and it amounted to 45.6% of the average EU GDP.

Following the Accession Conference with Croatia at deputy level of 30 October 2008, there are four provisionally closed chapters:

- Enterprise and industrial policy (Chapter 20)
- Science and research (Chapter 25)
- Education and culture (Chapter 26)
- External Relations (Chapter 30),

with negotiations having been opened in 21 chapters (status on December, 2008). At the moment, there is a significant standstill in negotiations, with Slovenia blocking the continuation of negotiations due to border disputes at sea and land. On the other side, recent Croatia's membership in NATO is one significant step in improving the country's European integrations and will in future have influence in defining transport policy, especially at sea. Due to its geographic position, RC is included in the EC program "Marco Polo II" and is taking part in the activities in the maritime corridor "Motorway of the Sea South-East Europe" based on the EC Transport White Paper of September 2001. These motorways should be part of the Trans-European Network (TEN-T).

The following two figures clearly show that road transport, although environmentally rather challenging, prevails in the transport sector in Croatia, while the share of environmentally more suitable railway transport is less than 13% (in the transport of goods), although more favourable in the transport of passengers (44.2 %). Furthermore, the share of inland water transport in negligible (bellow 1%) leaving a lot of room for improvement, where EU investment structural measures can have a very significant role. The share of air transport

of passengers is 1.6%, while the air transport of goods is negligible, what leaves a lot of space for improvements and investments in the rather vacant field.

Figure: Structure of Transport of Passengers by Mode of Transport, 2007 (source: Croatian Central Bureau of Statistics, Statistical Information 2008)

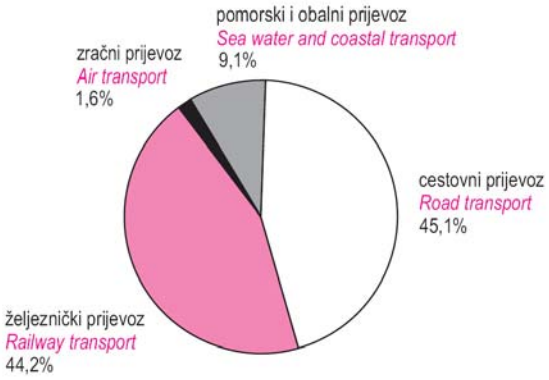
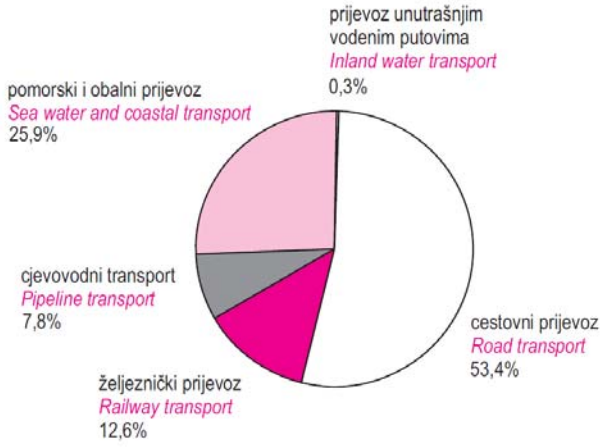


Figure: Structure of Transport of Goods by Mode of Transport, 2007 (source: Croatian Central Bureau of Statistics, Statistical Information 2008



Inland Waterways

Total length of waterways in RC is 804.1 km of which 539.2 km are international and 264.9 km are state and interstate waterways. Of all international inland waterways, 286.9 km satisfy class IV for international waterways.

European action plan for inland waterways has been integrated into the Strategy of Development of Inland waterways in RC (2008 – 2018) where 6 significant areas have been defined:

1. security of waterways and ecology

2. market
3. infrastructure
4. shipbuilding, education and new workspaces
5. publicity and advertising
6. improvement of administrative ability

In the area of inland waterways transport, Republic of Croatia has signed and ratified the European Agreement on the Main International Waterways (AGN) that includes mayor inland waterways on rivers Sava, Drava, Danube and future canal Danube – Sava into the network of European waterways. This also includes the integration of harbours in Osijek, Vukovar, Slavonski Brod and Sisak into the network of harbours opened for international traffic. The same contract has obliged RC to establish and maintain international waterways on its territory in accordance with prescribed standards under categories IV. to V.b. Croatia has also signed European convention on international traffic of hazardous substances in inland waterways (ADN) and Convention of Budapest (CMNI). Croatia has accepted the Convention on regime of Danube navigation, as the successor of previous state. The recommendations of Danube Commission, as well as appropriate UN resolutions, have been included into the legal system.

Rail Transport

The total length of all railway lines in RC is 2722.41 km, of which 2468.54 km (90.7%) are single gauge and 253.87 km (9.3%) double gauge. Electrified are 980.07 km (36.0%). The total length of all gauges is 4098.11 km of which 3635.84 km (88.7%) are in use.

In the field of railway transport, RC has joined COTIF and become active member of International Union of Railways (UIC), European Conference of Ministers of Transport (CEMT) and Intergovernmental Organization for International Transport by Rail (OTIF).

The need to adjust EU legal system has required the issuing of new draft for proposal of Legal Act on Railways that would create conditions for full integration of Croatian railways into the EU railway market. This will be accomplished by accepting and taking into account all principles derived from European legal acts, primarily EU Directives applied in the field of railway traffic and their implementation into the text of this Draft proposal. The most significant are Directive 91/440/EEC on railway development, Directive 5/18/EC on issuing certificates to railway transport companies, Directive 2001 /14/EC on distribution on railway infrastructure and applying commercial fees.
The integration of Croatian Railways into the network of EU railways is to be performed in two areas:

- legislative – through development of legal and normative conditions for integration of RC into EU by respecting the acquis communautaireu in this area and

unification of business environment with the business policy of EU (interoperability)
- technical - including infrastructure, transport means, traffic management and logistics.

Road Transport

RC has signed the following major conventions and agreements regulating road transport activities. RC has accepted the majority of the international conventions in the field of road transport, through the notification of succession, such as: TIR Convention (1991); European Agreement concerning the Work of Crews of Vehicles Engaged in International Road Transport (AETR, 1995); Convention on the Contract for the International Carriage of Goods by Road (CMR, 1992); European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR, 1993).

Air Transport

There are seven airports in the RC – Zagreb, Split, Dubrovnik, Zadar, Rijeka, Pula and Osijek that are used in the international air transport and are mostly in the state property (55% of the shares). In addition, there are three smaller airports (Osijek, Brač, Mali Lošinj) used by the smaller commercial aircrafts.

In the air transport, RC has inherited large number of signed International conventions and bilateral agreements as one of the successors of former state. In addition, there are number of conventions in the area of security of air transport (EUROCONTROL) together with different protocols, such as those since 1970, 1978 and 1981. Based on three international contracts, RC is member of the following international organizations: International Civil Aviation Organisation (ICAO) since 1992, European Civil Aviation Conference (ECAC) (1992), European Organisation for Safety of Air Navigation (EUROCONTROL) (1997). Croatia is the full member of Joint Aviation Authorities (JAA) (2004). In 2006 there has been signed the Working Arrangement between European Aviation Safety Agency (EASA) and the Transport Inspection Directorate of Ministry of Sea, Tourism, Transport and Development RC, on gathering and exchange of information on the safety of aircraft using Community airports and airports of RC. The new agency Croatian Civil Aviation Authority (CCAA) has been established in 2008 that contributes to adjustment of national air transport system safety to European standards.

Maritime Transport

In the field of maritime transport, RC has signed Paris Memorandum in 1997, and based on notifications on succession (1991) has inherited numerous international treaties among

which the most important are United Nations Convention on the Law of the Sea (1982) Convention for the High Seas and Convention on the Territorial Sea and the Contiguous Zone (1958), International Convention for the Safety of Life at Sea (1974), International Convention on Load Lines (1966) and numerous others. As Adriatic Sea is relatively closed and with a very large number of islands, with Croatia highly dependent on tourism, the environmental protection of sea and seacoast is of utmost importance. Therefore, RC has signed and is implementing the following treaties: International Convention on the Prevention of Pollution from Ships, London, (1973) and Protocol relating to the International Convention for the Prevention of Pollution from Ships (1978). Based on the Notification on succession in 1993 (Official Gazette – Narodne novine 12/93), RC has inherited the following international treaties: Convention for the Protection of the Mediterranean Sea Against Pollution (1976) and two Protocols (1980, 1982). Although the conventions, treaties and protocols stated here are only the most important, there are numerous others derived or legally based on them.

2.1.2 The elements of Transport research policy making

Taking into consideration the processes of stabilization and accession of the Republic of Croatia to the European Union, the Government of the Republic of Croatia is confident and determined in its intention to build Croatia into a science and technology-oriented country. It also takes into account that the general trends of globalization processes of the world, stress out the competitiveness of national economies as the major factor of societal progress. Admission into full membership of the EU community of states is Croatia's national interest. The underlying EU document for national strategies of member countries is the *Lisbon Strategy*. This Strategy conveys as major goals stronger and more stable economic growth, which further implies opening of a larger number of high-quality jobs[3]. Furthermore, there is a strong tendency to replace energy and capital with knowledge and information as the primary wealth-creating assets.

In 2001, the Government launched the *Croatian Programme for Innovative Technological Development (HITRA)*, targeting for the first time science and industry cooperation with the goal of boosting public-private partnerships. HITRA is targeted at initiating the national innovation system through permanent development of three strategic and long term goals[4]:

- Fostering science and industry cooperation
- Revitalization of industrial R&D
- Encouraging commercialization of research results

[3] Science and Technology Policy of the Republic of Croatia 2006 – 2006, Republic of Croatia, Ministry of Science, Education and Sports, Zagreb, 2006
[4] Science and Technology Policy of the Republic of Croatia 2006 – 2006, Republic of Croatia, Ministry of Science, Education and Sports, Zagreb, 2006

HITRA provides a framework for direct cooperation between industry and entrepreneurs with higher education institutions and research institutes, and is implemented through two complimentary sub-programmes: TEST and RAZUM.

- *Technology-related research and development projects (TEST*) - which provides support to development of new technologies, in terms of products, processes or services, up to their commercialization stage
- *Development of knowledge-based enterprises (RAZUM*) - which provides early stage financing knowledge and technology based start-ups

Between the years 2001 - 2005, close to €30 million has been invested in HITRA technology projects with the outcome of several projects being close to market exploitation. Both programmes are currently in the process of refinement, and implementation has been entrusted to professional technology management corporations, Business Innovation Center of Croatia, BICRO Ltd., and the Croatian Institute for Technology, HIT Ltd., to ensure quality and transparency in the decision-making process. HIT Ltd. was founded in March 2006, as an expression of the need to transform and amplify activities of the existing Institute for Technology Policy and Development. The mission of HIT is to create pre-conditions for accelerated application of new knowledge and technologies, by providing services, expertise and projects. HIT operates in the field of financial support to technology based and innovative entrepreneurs and coordinates cooperation with European-funded projects. HIT provides consulting services in the area of technology transfer and knowledge, and coordinates institutions in similar areas of work, with the aim of enforcing technological development on a national level. Furthermore, HIT provides expert advice in establishing *start up* and *spin out* companies, whereby the main criteria are innovation, development of new technologies and market logic and profitability of the new companies. HIT's tasks include building a *Business Intelligence* system and technology forecasting.

The Government will remain a key investor in the science infrastructure, fundamental research, and education, which influences the strength of the innovation system, but shall also create conditions for collaboration between academia and business, facilitate exploitation of research by other sectors such as transport, energy and health care, and encourage the adoption of technology to improve industries. The Government shall actively encourage private sector investment into R&D by offering matching grant schemes. The Government shall work on creating a favourable climate for private sector investment into R&D by proposing favourable tax legislation to the Parliament, and shall also work to simplify the administrative procedures and remove bureaucratic barriers which prevent rapid development of enterprises.

There is a long history of Intellectual Property protection in Croatia (since 1884), as well as significant existing legislation, making Croatia a regional leader. *A* National Strategy for Development of the Intellectual Property System in Croatia has been drafted by the State Intellectual Property Office (SIPO) and accepted by the Government in 2005. The short-term goal of this strategy is to provide IPR protection comparable to EU level, and the mid-term goal is to ensure application of IPR as a lever for economic growth, up to the standards of EU countries with the highest European Creativity Index (ECI). An IP Unit has been set up within the Ministry of Science, Education and Sports, that oversees projects related to the raising of awareness on IPR issues, as well as activities related to setting up of 3 IP centres within academic and research institution.

Ministry of Sea, Transport and Infrastructure (MSTI) and subordinated bodies are responsible for creating and enforcing transport policies, primarily national strategy of particular transport sectors, creating infrastructural development climate, coordination of all activities connected to transport and participation in creating traffic security policy, as well as constant monitoring of environmental effects and reduction of these. This Ministry has eight Directorates, each one responsible for one aspect of transport policy (e.g. road transport, air transport, railway transport etc). Although transport, together with telecommunications, is primarily within the jurisdiction of Ministry of Sea, Transport and Infrastructure (MSTI), certain aspects of infrastructural design, traffic safety and jurisdiction within e.g. inland waterways are systematically not within MSTI but other governmental bodies.

Republic of Croatia, in the field of transport, is trying to implement acquis communautaireu in the following areas: market availability, synchronisation of taxation system, social legislation, technology, safety and security, environment and transport of dangerous and toxic substances.

Politics of road transport is defined by the Directorate of Road Transport within MSTI that performs all administrative and professional duties within road transport and public roads sector, assures enforcement of the defined policy and legislation in the field of road transport and public roads and prepares drafts of legislative documents in this field.

Railway transport in RC is under competency of Railways Directorate within MSTI that performs supervision of implementing legislation in this field, including inspection of legislation practice and all other activities aimed at safety of railway transportation.

Directorate for Inland Waterway Navigation, within MSTI, performs:

- inspection in accordance with actual legislation of nautical aspect of navigation safety
- technical inspection of navigation safety
- naval engineering aspects of navigation safety
- hydro-civil engineering aspects of navigation safety

- protection on inland waterways from vessel's pollution
- assessment and inspection of living and working conditions of ship's crew
- surveillance of waterway's estates and concession system on these assets.

In addition, this directorate prepares drafts of legislation proposals, as well as other legal acts considering safety, navigation, inland harbours, accident reports and statistics. Furthermore, they conduct supervision of Croatian Registry of Shipping in the area of inland boats safety, participate in the work of international associations and committees and propose policy and measures regarding economical development of inland waterways transport. In addition, they work very closely with Water Management Directorate at Ministry of Agriculture, Forestry and Water Management and Agency for Inland Waterways. Key role in the daily administering of the whole process is provided by the inland Port Authorities in Sisak, Slavonski Brod, Osijek and Vukovar.

There are seven airports in the RC – Zagreb, Split, Dubrovnik, Zadar, Rijeka, Pula and Osijek that are used in the international air transport and are mostly in the state property (55% of the shares). In addition, there are three smaller airports (Osijek, Brač, Mali Lošinj) used by the smaller commercial aircrafts.

Civil Aviation Authority (CAACRO) is an autonomous unit within MSTI that performs administrative and other professional duties pertinent to air transport, such as:

- preparation of legislation drafts and other acts
- gives guidelines for transport policy of air transport development and assures its administering
- prepares proposals of international contracts and agreements
- issues certificates and other legal documents necessary for professional activities for aeronautical and other personal
- issues approvals for aircraft certification, etc.

Within CAACRO the following Departments are established:

- Department of Legal and International Affairs
- Department of Air Traffic, Flying Standards, Airworthiness and Staff Licensing
- Department of Airports and Air Transport Security

One of the entities within CAACRO is also the Croatia Control, a state-owned limited liability company that operates independently in the Republic of Croatia, with the primary mission to provide air navigation services, pursuing the basic principle of a high level of air traffic safety. In the provision of air navigation services to the institutions in neighbouring countries it adheres to the principles and procedures of ICAO (International Civil Aviation Organisation) and EUROCONTROL (European Organisation for the Safety of Air Navigation).

Besides, since March 2009, new organization, Croatian Civil Aviation Agency (CCAA), will take part of the responsibilities from CAACRO and improve the following elements of the air transport:

- communication with the industry,
- implementation of written standard procedures of the Agency, mandatory and equal for everyone,
- increase of professional capacity of the Agency,
- increase activities in air traffic management and safety.

The basic goal of the CCAA is to provide adequate environment for performing civil air transport in the Republic of Croatia, by defining necessary regulations and through supervision over implementation of positive legal and professional standards, in order to maintain and perform safe flying and high standards of air traffic management. Agency will be a service to all air traffic subjects by ensuring achievement of required standards of operation and will act positively and encouraging to commercial development and increase of flying safety standards. Agency will actively represent the Republic of Croatia in international bodies, maintaining national interests, as well as interests of organizations and citizens of Croatia.

Department of Air Transport Inspection, as a part of CAACRO, performs inspection of proper administering of all regulations relevant to aircrafts, ground and in-flight equipment, air traffic, airports and airport services, etc.

Directorate for Maritime Policy within MSTI has been established with internal Departments that guarantee administering of legislation and other legal acts within their jurisdiction, such as:

- Department of Legal and International Affairs
- Department of Maritime Transport
- Department of Sea Harbours and Maritime Assets
- Department of Technical Affairs and Traffic Safety

The territorial distribution of responsibility is through eight units within Directorate – these are State Port Authorities in Rijeka, Zadar, Šibenik, Split, Ploče and Dubrovnik, additionally supported by 22 County Port Authorities located in smaller coastal cities. Inspection of appropriate administering of all activities is under jurisdiction of Inspectors of Maritime Transport Safety, who are employees of MSTI or Port Authorities.

According to the latest data, there are 3232 Masters of Science, 5780 Doctors of Science and 1982 other researchers in the Republic of Croatia. Industry and private companies employ 2703 M.Sc.'s and 976 D.Sc.'s.

The R&D and higher education sector consists of:

- 26 public institutes, 13 private scientific institutions, 6 technology and research and development centres, 11 research centres in industry, and one military research centre

- 7 universities, 16 public colleges and polytechnics, and 16 private colleges and polytechnics which are accredited

Table : Published Dissertations (Technical sciences only), source:MSES, http://bib.irb.hr/skupni_podaci:

Year	2004	2005	2006	2007	2008	2009
No. of Dissertations	86	84	62	74	52	6

2.2 Overview of Transport research activities

2.2.1 Transport research projects

Besides the Ministry of Science, Education and Sports, the National Science Council and the National Council for Higher Education monitor the development and quality of the entire sector, as the highest professional and advisory bodies appointed by the Croatian Parliament. The Parliament also appoints the Ethics Committee for Science and Higher Education. Within the system, there are several independent specialized institutions: National Foundation for Science, Higher Education and Technological Development, the Agency for Science and Higher Education, Business Innovation Center of Croatia - BICRO Ltd., Croatian Institute of Technology Ltd. - HIT. Apart from the listed institutions there are 5 state agencies competent in the area of statistics, intellectual property, hydrometeorology, metrology and accreditation. The Croatian Academy of Sciences and Arts - HAZU and “Miroslav Krleža” Lexicographical Institute enjoy the status of scientific institutions of special interest in the Republic of Croatia. Besides HAZU, there are two specialized academies: Academy of Medical Sciences of Croatia and the Croatian Engineering Academy.

Table: Resources for research and development - in thousand HRK (source: Statistical information 2008, Republic of Croatia, Central Bureau of Statistics, Zagreb, 2008)

	2004	2005	2006
Own resources	812 731	663 432	629 197
Government and local administration	1 121 859	1 261 075	1 131 053
Private and public enterprises	565 371	326 076	265 037
Non-profit institutions	-	1 166	4 842
Other domestic resources	20 577	-	-
Foreign investors	66 148	59 963	149 031

Total	**2 586 686**	**2 311 712**	**2 179 160**

The *Technology-Related Research and Development Programme - TEST*, administered by the Croatian Institute of Technology, is targeted at academia and research institutions, and provides financial support to the development of new technologies, as well as complex projects for technological development such as prototype, pilot solution, accredited laboratories and intellectual products.

Table: Researchers in full-time employment (source: Statistical information 2008, Republic of Croatia, Central Bureau of Statistics, Zagreb, 2008)

	2004	2005	2006
Business sector	1160	867	851
Government sector	2442	2120	2129
Non-profit sector	-	3	2
Higher education	5872	5238	5462
Total	**9474**	**8228**	**8444**

Besides *Technology Projects*, further sub-categories of this programme are *Complex Technology Projects (STIRP)* that are focused on multidisciplinary, precommercial and cooperative research, and *JEZGRA Projects*, which are aimed at creating centers of excellence in research and technology, based on public-private partnerships. €2.8 million has been secured in the state budget for 2006, for implementation of this programme

The new *RAZUM* activity is an *Innovation Commercialization Programme,* administered by BICRO, which aims to ensure a sustainable increase in the number of knowledge-based enterprises. It shall serve as a seed fund for development of knowledge-based private or largely private enterprises that are using traditional technology and/or are technology based companies that are expected to have a significant favourable impact on economic development.

Table: Croatian participation in FP7 – Projects on the main list (source: FP7 Programme Committee Transport)

Proposal Number	FP7 Call	Applicant Total Cost (in Euros)	Applicant Requested Contribution (in Euros)
212991	FP7-SST-2007-TREN-1_05June	206.897,00	206.897,00
218362	FP7-SST-2007-TREN-1_05June	136.813,00	102.299,00
218589	FP7-SST-2007-TREN-1_28June	1.603.160,00	1.022.890,00
218954	FP7-SST-2007-TREN-1_28June	1.998.260,00	1.090.630,00
218954	FP7-SST-2007-TREN-1_28June	114.960,00	64.620,00
218954	FP7-SST-2007-TREN-1_28June	627.960,00	327.540,00
218954	FP7-SST-2007-TREN-1_28June	437.680,00	310.040,00
218954	FP7-SST-2007-TREN-1_28June	104.600,00	67.800,00
218954	FP7-SST-2007-TREN-1_28June	357.540,00	206.160,00

218954	FP7-SST-2008-RTD-1	61.813,00	61.813,00
234106	FP7-SST-2008-RTD-1	265.920,00	210.080,00
233969	FP7-SST-2008-RTD-1	178.000,00	137.500,00
234277	FP7-SST-2008-RTD-1	251.740,00	190.940,00
234070	FP7-SST-2008-RTD-1	188.380,00	141.660,00
233884	FP7-TPT-2008-RTD-1	152.800,00	100.645,00
234146	FP7-TPT-2008-RTD-1	149.760,00	99.312,00
Total		**6.836.283,00**	**4.340.826,00**

Croatian partners:

	governmental bodies, city councils and companies under their ownerhisp
	companies, private institutes, SMEs
	Universities

Calls included within this survey:

- AAT-2007 and 2008
- SST-2007 and 2008
- TPT-2007 and 2008
- SST-2007-05June and SST-SST-2007-28June
- Galileo

Table: Financed scientific projects and programs (launched in 2006/2007), source: MSES

Scientific fields	No. of financed programs	No. of financed projects	Allocated grants (in HRK)
Natural Sciences	50	364	34.375.400
Technical Sciences (Engineering and Technology)	65	397	34.146.000
Biomedicine and Health	66	571	38.666.000
Biotechnical sciences	39	274	18.080.000
Social sciences	49	366	13.957.000
Humanities	50	336	13.005.000
Total	**319**	**2308**	**152.229.400**

Table: Gross domestic expenditures in research and development – in thousand HRK (source: Statistical information 2008, Republic of Croatia, Central Bureau of Statistics, Zagreb, 2008)

	2004	2005	2006
Business sector	1 077 390	953 523	799 891
Government sector	541 141	555 341	577 682
Non-profit sector	-	2 968	3 107
Higher education	968 155	799 880	798 480
Total	**2 586 686**	**2 311 712**	**2 179 160**

Some of the most prominent companies with significant transport research sector are:

AVL AST Ltd. is part of the AVL consortium (www.avl.com) that is privately owned and independent company active in the development of powertrain systems with internal combustion engines as well as instrumentation and test systems. The Croatian office is active in the field of simulation methods, numerical stress analysis and software development. Their research staff counts around 40 electrical, mechanical, naval and aeronautical engineers.

KONČAR Institute (www.koncar-institut.hr) is a large research institution with 116 (75%) employees with university degree (Dipl. Ing. or BSc), 18 (12%) with MSs or Dr. Sc. degree. Applied research and product development make 65% of business activities Research and development has been funded with 0.9 million Euros (all data for year 2007). The Institute is mostly involved in applied research and development of equipment, technologies and services for efficient and reliable energy conversion and power transmission based on the principles of socially responsible business. The long term goal of the Institute is to become regional leader in the development of specific products and equipment applying up-to-date technologies, as well as testing, diagnostics, monitoring and analysis of electrical equipment and systems for electric power sector and electrical vehicles.
Most significant R&D is in the field of:

- power converters and controls for low-floor tram (main contractor for low floor tram is KONČAR Electrical Vehicles)
- auxiliary power supply converters for electric locomotive drives
- four-system converters for passenger cars

For the future project of commuter train (future project) development is in the areas:

- main drive converter
- auxiliary power supply converter with battery charger
- central control and communication system
- intelligent controller

Departments:

- Transformers Department
- Rotating Machines Department
- Switchgear and Controlgear Department
- Materials and Technology Department
- Power Electronics and Control Department
- EMC, Safety and Calibration Department

Uljanik Shipyard (www.uljanik.hr) is active in the field of construction of sophisticated ships for special purpose for dry and liquid cargo and for more demanding buyers on the world's market. The specialization makes them less vulnerable to competition in the market, but at the same time more investment in new technologies and research is demanded. Since its foundation in 1856 the Shipyard has been developing the shipbuilding activity, the high technological level of which has been achieved and

confirmed by generations of employees through many years and by the floating units of top quality built, thus procuring international references and reputation which should be further on increased through:

- a profitable business activity;
- the construction of ships to special orders of highest world's quality, low costs in service and long lifetime;
- the construction of sophisticated ships for special purpose for dry and liquid cargo and for more demanding buyers on the world's market;
- the construction of ships in competitive, shortest possible times with obligatory observing of the contractual delivery terms;
- quality, terms and price and a further promotion of the international reputation and recognition of the Shipyard.

2.2.2 Key competencies in Transport research fields

The interdisciplinarity of the transport sector is noticeable in the number of projects and institutions where the research has been performed. As expected, the largest number of projects has been allocated to the Faculty of Transport and Traffic Sciences, due to its inherent link and specialisation to the field of transport. However, some other institutions such as the Faculty of Mechanical Engineering and Naval Architecture are also very active in this field. As expected, quite often the projects are interdisciplinary, and the dominant topic is different to distinguish even by the keywords in the its description.

Based on the MSES Project database, the dominant areas of the research are:

- Acquis Communautaire in transport
- Ecological aspects of transport (e.g. problems of noise, pollution, emission of toxic and environmentally harmful products)
- Intermodal transport and integration of RC into European transport area
- Traffic control in urban areas
- Integration of maritime and inland harbours
- Modelling of transport development
- Research on new types of fuels (hydrogen or bio-fuels) in urban transport or other means of transport
- Traffic security and safety of means of transport
- Information-communication technologies in intelligent transport systems
- Electronics and microprocessors in means of transport
- New and advanced materials engineering in the means of transport
- Ecological aspects and safety of maritime structures
- Advanced simulations of mechanical behaviour of means of transport

Table: Projects related to the field of transport (financed by MSES 2006 – 2009) (source: MSES database)

Institution	No. of projects	No. of researchers
Faculty of Transport and Traffic Sciences, Zagreb	13	146
Faculty of Mechanical Engineering and Naval Architecture, Zagreb	10	57
Faculty of Maritime Studies, Rijeka	8	82
Faculty of Electrical Engineering and Computing, Zagreb	5	63
Faculty of Civil Engineering, Zagreb	3	24
Faculty of Maritime Studies, Split	2	24
Faculty of Electrical Engineering, Osijek	1	16
Croatian Academy of Sciences and Arts	1	5
Civil Engineering Institute of Croatia, Zagreb	1	9
Institute of Transport and Communications, Zagreb	1	12
Faculty of Science, Split	1	7
Total	**46**	**445**

The topics represented through the Technological projects, where the most active research institution is Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, are:

- Numerical modelling of damage and safety of aeronautical structures
- Special purpose marine and river vessel designs
- Numerical modelling of road vehicle dynamics

Table: Technological projects related to the field of transport (financed by MSES 2006 – 2009) (source: MSES database)

Institution	No. of projects	No. of researchers (participants)	Grants in HRK
Faculty of Mechanical Engineering and Naval Architecture, Zagreb	4	29	3 782 350
Brodarski Institute, Zagreb	1	12	288 000
Faculty of Metallurgy, Sisak	1	17	200 000
Faculty of Engineering, Rijeka	1	5	1 564 040
Total	**7**	**63**	**5 834 390**

All scientific projects are financed by the MSES, but the funding system for scientific research is scattered, with rather small amounts allocated to each research, especially if the number of researchers is large. These projects are mainly focused on fundamental research were the final outcome is not commercial. On the other side, through financing of the Technological projects, MSES is trying to achieve tangible output in the form of new products, usable methodologies or procedures, that are potentially commercialised. These projects are allocated larger amount of money, where the share of work and

equipment costs is significant. In the meantime, the whole procedural activities are done by HIT (Croatian Technology Institute) including the approval of the projects and monitoring of their progress. These projects have as a side effect the possibility of employing research assistants for a limited amount of time (two or three years) that way increasing the research basis of the scientific community as some of these researchers continue their work on scientific projects.

2.2.3 Transport research infrastructure

The most relevant institnutions of importance for transport research and transport in general are the following:

CROATIAN CHAMBER OF ECONOMY (www.hgk.hr) is an independent professional and business organisation of all legal entities engaging in business. The Croatian Chamber of Economy consists of the Headquarters in Zagreb and 20 county chambers. Among these, the Zagreb Chamber represents both the City of Zagreb and Zagreb County. Functionally, the CCE consists of 8 departments dealing with the respective branch of the economy, and it also includes 40 professional associations, 87 groups and 19 affiliations. Apart from this, within the CCE act five business centres, Permanent Arbitration Court, Conciliation Centre, Court of Honour and CCE Office for Areas of Special State Concern. One of the most important tasks of the Chamber is the improvement of economic co-operation with foreign countries. This is achieved through various activities aimed at increasing the exchange of goods and services, and also at making improvements in all other forms of economic co-operation with business actors abroad.

Ministry of Science, Education and Sports MSES (www.mzos.hr) has the goal to create the conditions for a quick and successful transformation of scientific results and technological innovations into products competitive on global markets, to foster international technology transfer as well as the development of technology-based small and medium enterprises. Innovations and new technologies are considered to be the key factors in the economic and social development at the beginning of the 21st century. Considering this, the activities of the Directorate for Informatics and Technologies are focused on the implementation of the two basic programs:

- the establishment of the national network of institutions focused on the development, transfer, application and financing of new technologies
- the development of the system of the Government measures supporting technological development and innovative entrepreneurship such as various financial, fiscal, administrative and similar benefits and incentive programs.

Within the national technological network the following institutions have been established so far:

- Business Innovation Centre of Croatia - BICRO Ltd.
- Croatian Institute of Technology – HIT Ltd.
- Centre for Karst

- Technology and Innovation Centre Osijek Ltd.
- Centre for Innovative Technology Rijeka Ltd.
- Technology Centre Split
- Centre for Technology Transfer
- Research and Development Centre for Mariculture.

Faculty of Mechanical Engineering and Naval Architecture FMENA (www.fsb.hr) is the institution within University of Zagreb whose main activities are education of engineers and scientists, research and production of knowledge and application of knowledge in practice, based on the unity of science, education and education. FSB is running university undergraduate and graduate educational programs: Mechanical Engineering as the basis of all generic techniques, material culture and culture in Overall, the studies of Naval Engineering and Aeronautical Engineering as complementary components. In its activities FSB wants to be a modern and attractive middle-European Technical University, the best in our country, and comparable with prominent foreign colleges of similar activities, based on its recognition and 80-year tradition.
Organisations:

- Department of Design
- Department of Engineering Mechanics
- Department of Thermodynamics, Thermal and Process Engineering
- Department of IC Engines and Mechanical Handling Equipment
- Department of Energy, Power Engineering and Environment
- Department of Naval Engineering and Marine Technology
- Department of Industrial Engineering
- Department of Quality
- Department of Robotics and Production System Automation
- Department of Materials
- Department of Welded Structures
- Department of Technology
- Department of Aeronautical Engineering

Faculty of Electrical Engineering and Computing (FEEC) (www.fer.hr) - in the last few decades research and development at the Faculty has been carried out through projects promoted and funded by the Croatian Ministry of Science, Education and Sports in the fields of Applied Physics and Mathematics and in the fields of Electrical Engineering and Computing. With 19 approved scientific programmes and 71 approved scientific projects in 2007 the Faculty represents the leading institution in the fields of Electrical Engineering and Computing in Croatia. Additionally, researchers of the Faculty are currently leaders of 4 technological and 13 information projects for the Ministry, as well as the leaders of a number of industrial projects and projects with other partners. Determined to remain a respectable research institution, FER undertakes scientific research at the highest levels of international standing. The Faculty has developed valuable international cooperation with many research institutions around the world, either directly or through inter-university cooperation. The number of international projects in the academic years 2005/2006 and

2006/2007 reached 47 projects, 11 of which are FP6 projects, which makes Faculty of Electrical Engineering and Computing one of the most internationally active institutions in Croatia.
Organisations:

- Department of Applied Physics
- Department of Applied Mathematics
- Department of Applied Computing
- Department of Electric Machines, Drives and Automation
- Department of Power Systems
- Department of Telecommunications
- Department of Electronic Systems and Information Processing
- Department of Control and Computer Engineering in Automation
- Department of Electroacoustics
- Department of Electronics, Microelectronics, Computer and Intelligent Systems
- Department of Radiocommunications and Microwave Engineering
- Department of Fundamentals of Electrical Engineering and Measurements

Faculty of Transport and Traffic Sciences (www.fpz.hr) provides university education in all branches of transport, including new applications of ITS, intelligent transport systems and logistics. Cooperation with leading world and European Universities transport engineering and logistics creates the conditions for creative action in solving traffic and transport-logistic problems, including Croatia and its environment.
Organisations:

- Department for Road Traffic
- Department of Transportation
- Department of Information and Communication Traffic
- Department of Postal Traffic
- Department of Traffic Planning
- Department for Traffic and Technical Expertises
- Department of Water Transport
- Department of Civil Aviation
- Department of Rail Transport
- Department of Intelligent Transport Systems
- Department of the Street Signs
- Department of Transport Logistics
- Croatian Aviation Training Center
- Department of Aeronautics

Faculty of Maritime Studies Rijeka (www.pfri.hr), University of Rijeka, is a maritime education and training institution specialized in marine-oriented programmes at the undergraduate and graduate levels, with particular emphasis on:

- preparing officers for the seagoing career in nautical and marine engineering studies
- shipping and transportation logistics/management

- transport technology
- maritime communications and marine electronics.

The mission of the Faculty is to provide an educational and scientific environment which stimulates intellectual curiosity and fosters professional competence. Furthermore, the Faculty prepares students for research in maritime transport, maritime education and training and in the protection in the marine environment.
Organisation:

- Department of Navigation and Safety at Sea
- Department of Marine Engineering and Ship Power Systems
- Department of Marine Electronics and Communications
- Department of Maritime Transportation
- Department of Logistics and Management
- Mathematics and Natural Science Department
- Department of Maritime Law
- Foreign Languages Department
- Department of Social Studies and the Humanities

Faculty of Maritime Studies Split (www.pfst.hr) is the only scientific-teaching component of the University of Split, which in June 2000 received the quality certificate ISO 9002 from the classification societies Bureau Veritas and the Croatian Register of Shipping for higher education and training, research and professional papers and publications. Education is in accordance with the requirements of STCW Convention and the Regulations on Vocations and the certificates of qualifications of seamen in the merchant navy ships of the Republic of Croatia.
Organisation:

- Department Maritime Marine
- Department of Marine Engineering
- Department of Electrotechnical and Marine Information Technology
- Department of Marine Systems and Processes
- Department of Marine Technology of Yachts and Marina
- Department of Marine Management

Croatia Control Ltd (www.crocontrol.hr) is a state-owned limited liability company that operates independently in the Republic of Croatia, pursuant to relevant laws and company acts. In the provision of air navigation services to the institutions in neighbouring countries it adheres to the principles and procedures of ICAO (International Civil Aviation Organisation) and EUROCONTROL (European Organisation for the Safety of Air Navigation). The primary mission of Croatia Control Ltd is provision of air navigation services, pursuing the basic principle of a high level of air traffic safety.

Faculty of Civil Engineering (www.grad.hr) consists of nine divisions which provide teaching, scientific and vocational knowledge-based activities. Departments are run by Heads of Departments:

The Faculty consists of nine divisions:

- Geotechnical Engineering
- Materials
- Water Research
- Structures
- Mathematics
- Construction Management
- Transportation Engineering
- Engineering Mechanics
- Buildings

Scientific-research work is being carried out within the framework of numerous scientific projects. Most of them are financed by the Ministry of Science and Technology and the rest by the public enterprises, such as Croatian Water Resources Management, Croatian Roads, etc. In the majority of these projects applied research is carried out. Around thirty young scientific researchers also work on these projects, and are at the same time completing their postgraduate studies. The projects results have been published in numerous domestic and foreign journal and conference proceedings.

Vehicle Center of Croatia (CVH) (www.cvh.hr) has been in charge of vehicle technical inspection in the Republic of Croatia for almost 30 years. All stations for vehicle technical examination are part of the uniform vehicle technical examination system run by CVH. The Vehicle Center of Croatia takes care of education and training of employees of stations for vehicle technical examination (STP), furthermore, it checks their knowledge and skills, it provides maintenance and measurements for STP's devices and equipment, it introduces new technologies into the process of vehicle technical inspection etc.
Besides vehicle technical inspections, in stations for vehicle technical inspection, you can carry out all other activities necessary for the vehicles to take part in traffic, including mandatory vehicle insurance, payment of the yearly road fee as well as the environment fee, vehicle registration etc.

Brodarski Institute (www.hrbi.hr) is an advanced technology development organization that creates, transfers and applies knowledge to innovative products and services of high added value and quality on domestic and international market. The human resources of Brodarski Institute - its specialists of wide orientation and great professional competence, as well as numerous laboratories, measurement and other specialized equipment have enabled it to become a real center of technical science for Croatian economy. Thereby, crucial importance lies with fifty years of experience, which makes specialists from Brodarski Institute competent for establishing partnership with numerous economic factors in various fields. Besides the commercial activities, Brodarski Institute participates in scientific and R&D projects, and applied research projects from the HITRA program (Croatian Innovative Technological Development Program) at the Ministry of Science, Education and Sport (MSES). The HITRA projects are of vital importance for Brodarski Institute since the financing they provide enables support of R&D activities in creation of innovative products for Croatian economy.

Croatian Registry of Shipping CRS (www.crs.hr) is a heritor of ship classification activities at the eastern Adriatic coast. CRS is an independent, not for profit but common welfare oriented, public foundation performing:

- classification of ships;
- statutory certification of ships on behalf of the national Maritime Administrations;
- statutory certification of Marine Equipment;
- statutory certification of recreational crafts;
- certification / registration of quality management systems.

Hydrographic Institute of the Republic of Croatia (www.hhi.hr) carries out scientific-research, development and professional works concerning the safety of navigation in the Adriatic, hydrographic-geodetic survey of the Adriatic, marine geodesy, design and production of charts and nautical publications, oceanographic research, submarine geology research and finally publishing and printing activities.

The Institute is responsible for the development of navigational safety service in the Adriatic, in conformity with the recommendations of:
- International Hydrographic Organization (IHO),
- International Maritime Organization (IMO),
- International Association of Lighthouse Authorities (IALA)
and in cooperation with the Ministry of the Sea, Tourism, Transport and Development, Croatian Navy, port authorities, lighthouse authorities and hydrographic offices of all maritime states.

Boatbuilding Cluster (www.boatbuildingcluster.com) has been created in 2007 by 21 Croatian boatbuilding companies that decided to join forces and to establish the Croatian Boatbuilding Cluster. Group of 21 Croatian boat builders, marine industry manufacturers, equipment and material suppliers and related service providers have thus formed strong strategic alliance in order to provide more effective solutions to its clients. Cluster members collaborate in terms of shared resources and look at ways of becoming more competitive and efficient in the increasingly global market place.
A production program of the Cluster is quite diverse. It fulfils many sailing needs and preferences that comprise:

- sailing boats
- family motor yachts
- rubber boats
- canoes
- fifty meters yachts
- and more

Inland Navigation Development Centre (CRUP) (www.crup.hr) is formed with the purpose of:

- Development and modernization of inland navigation trough high-end technology solutions
- Integration of inland navigation in modern high quality supply chains
- Revitalization of Croatian rivers and ports
- Improving public image of inland navigation

Republic of Croatia Civil Aviation Authority (CAACRO) (www.caacro.hr) operates within the Ministry of Sea, Transport and Infrastructure. Administration of air traffic does administrative and other expert tasks related to air traffic, inspection tasks of air traffic safety, proposes the traffic policy of the development of civil aviation and ensures the implementation of the established policy in the Republic of Croatia. CAACRO determines legal and operational issues related to the use the Croatian air space and performs administrative supervision of civil aviation activities. It is also responsible for issuing of Airworthiness certificates for aircraft and systems.

Organization:

- The Department of Legal, Economic and Systemic Affairs
- Office of International Affairs
- Office of Flight Operations and Safety of Air Traffic
  i) Department of Air Force Personnel Licensing
  ii) Department of Aircraft Airworthiness
- Office of the airport and the protection of Air Traffic.

2.3 Key drivers of Transport research

2.3.1 Main Transport sector trends in Croatia

In the document Strategic Framework for Development 2006 – 2013[5], issued by Government of Republic of Croatia, the following trends in the development of transport have been defined:

- In the development of transport infrastructure, it is important to use all the advantages of geographical position of Croatia and natural inclination of the country to develop all modes of transport. The development of transport infrastructure must be focused on the increased integrity and intermodalitiy of the whole transport system - maritime transport and harbours, rail and road infrastructure, inland waterway and harbours, as to achieve the synergic effect on the development and competitiveness of economy. Better internal connection of transport system will improve the accessibility to the European transport corridors

[5] Strateški okvir za razvoj, 2006 – 2013, Vlada Republike Hrvatske,

and achieve better integration of Croatian traffic network with those of neighbouring countries.

- In the next period, investments into the traffic infrastructure have to be defined as to enable the decreasing of differences in the quality and safety between different segments of road infrastructure as well as different transport modes. It is necessary to modernize management and control of transport systems by using information – communication technologies in order to achieve synergy effects by combining road, rail, maritime and inland waterways traffic. In accordance with this, and taking into account the development of areas inclined to the harbours, investments into infrastructure of sea harbours should be focused to the increase of ro-ro and container capacities.

- The good coverage by road infrastructure, including the grid of highways, shows that in road infrastructure investment priorities would be maintenance of existing roads, as well as increase of quality and safety of state, county and local roads.

- Priorities in the modernization of rail infrastructure should be the rail routes of importance for the transport of goods that can assure additional boost to the development of maritime transport and sea harbours and strengthen the position of Croatia as transit area to the South Eastern Europe and further to Middle East. Modernisation of rail infrastructure should be based on the complementarity with other modes of transport, what also requires the closing of those rail routes that are not competitive compared to road and/or air transport. This will contribute to the preparedness of state company Croatian Railways to the competition on the unified market, the process that also requires the financial consolidation of Croatian Railways. Investment into rail infrastructure and traffic should be through using modern technologies in the control of transport as to assure safety, quality and reliability of this mode of transport. This would enable faster integration into European system of railway infrastructure management.

- The sustainable development of transport infrastructure with the purpose of competitiveness requires special attention in approaching problems of urban and sub-urban transport. It is necessary to develop system of instruments and measures that will encourage the usage of public transport network. In addition, in sub-urban transport it is necessary to strengthen the usage of non-road transport modes, such as rail transport, particularly in larger cities.

- The efficient revival of inland waterways transport requires the removal of bottlenecks at inland waterways, their interconnection, development of infrastructure in the harbours and improve the quality of navigation in accordance with international standards.

- The airport capacities are in case of Croatia significant factor in the tourism development. The improvement of capacities for passenger transport and

improvement of safety, security and quality of air transport, are necessary condition for full economic achievement and progress of this mode of transport.

Table: Republic of Croatia - GDP by sectors relevant to transport (2005)

Sector	Brutto Added Value (HRK)
Trade and Repair of Motor Vehicles	2.742.319.651,00
Surface and Pipeline Transport	6.546.809.721,00
Maritime and Inland Waterways Transport	1.287.682.159,00
Air Transport	383.667.250,00
Supporting and Auxiliary Activities in Transport	3.038.032.881,00
Production of Motor Vehicles, Trailers and Semi-Trailers	387.192.010,00
Production of Other Means of Transport	1.999.155.121,00
Total	**16.384.858.793,00**

Table: Promoted Dr.Sc. at University of Zagreb (academic year 2005 / 2006) in fields of relevance to Transport, source: Report on the activities of University in Zagreb, academic year 2005/2006

Scientific fields (Technical Sciences)	Promoted Dr. Sc.
Architecture and Urbanism	1
Naval Architecture	1
Electrotechnics	24
Geosciences	1
Civil Engineering	5
Graphic Arts Technology	4
Chemical Engineering	3
Computer Sciences	7
Mining, Oil and Geological Engineering	7
Mechanical Engineering	7
Traffic Technology and Transport	3
Textile Technology	2
Total	**65**

Table: Patent applications in 2007 by the field of technology (only relevant to transport) - source: State Intellectual Property Office of the Republic of Croatia – Annual Report 2007

Field of Technology Scientific fields (Technical Sciences)	Resident applicants	Non-resident applicants
Transportation	39	5
Machines or engines	19	5
Electrical engineering	13	1
Mechanical engineering	8	1
Total	**79**	**12**

Table: Capital equipment in the field of transport (source: MSES database: http://www.mzos.hr/dbApp/pregled.aspx?offset=435&appName=kapitalna#

Name	Provider	Institution
Marine Machinery simulator	Kongsberg Norcontrol Simulation AS - Horten,Norway	Higher Marine School, Split
Navigation Simulator	Kongsberg Norcontrol Simulation AS - Horten,Norway	Higher Marine School, Split
Full Mission Engine Room Simulator	Kongsberg Norcontrol Simulation AS - Horten,Norway	Higher Marine School, Split

2.3.2 Main socio-economic challenges in Croatia

Croatia, as a country that went through transition from socialist to capitalist economic system and at the same time establishing the independent state, has gone through many unfavourable processes. Although a lot has been achieved in the social, political and economical sector in Croatia, there are certain issues that challenge the prosperity and economical independence of the country:

- fiscal deficit and very strained state budget
- high unemployment rate (14.8%, 2008 est.)
- unfavourable workforce structure (only 8% with university degree)
- unfavourable ratio import / export and not enough competitive export sector with very small percentage of high technology products
- overall corruption coupled with inefficiency of judicial system
- high proportion of Public Debt in GDP (37.8 % of GDP in 2007)
- high proportional of Brutto Foreign Debt in GDP (89.1 % of GDP in 2007)
- over-reliance on tourism revenues
- very low level of innovativeness (ten times lower than in EU countries)
- discernible technological lag and unsatisfactory work productivity
- global financial crisis

3. Integration of Croatia in the European Research Area in the field of Transport

Admission into full membership of the EU community of states is Croatia's national interest. The underlying EU document for national strategies of member countries is the L*isbon Strategy*. This Strategy conveys as the major goals stronger and more stable economic growth, which further implies opening of a larger number of high-quality jobs.

The *Action Plan* (EC SEC 2005) covers ten major goals, wherein, under the common title "Knowledge for Growth", the following are listed:

- Increase and improvement of investments into knowledge, research and development
- Stimulation of innovation, expanding the use of information and communication technologies, and sustainable use of resources
- Knowledge-based society must strive towards realization of a healthy economy

Within the policy of increasing investments into research and development, the *Lisbon Strategy* anticipates increase of funds for research and development in individual member countries, as well as achieving the goal of 3% GDP allocation at EU level. It further anticipates improvement of off-budget and public investment ratio to 2:1.

The strategic tasks of the Croatia in the integration into EU research area are[6]:

- Increasing investments into research and development, and their efficiency
- Restructuring Croatia's science system
- Strengthening cooperation between science, government and industry in the creation of new knowledge and goods
- Increasing participation of Croatian scientists and other bodies in EU Framework Programmes

Therefore, in order to restructure Croatia's science system there are particular measures by the Ministry of Science, Education and Sports (MSES) in order to improve the:

- awareness on the significance and influence of science and research to society development (through educational system, media and special activities)
- interlinking of the research infrastructure with the purpose of more efficient use of potential (centers of excellence)
- clustering of existing scientific projects into integrated (collaborative) scientific programmes (collaborative centers of excellence) with the aim of creating internationally recognized and competitive centers of excellence, which are able to join the European network of scientists and businesses

So as to achieve these objectives MSES is included into the European research agenda through the following instruments[7]:

- TEMPUS: support for the reform of the higher education system (curriculum development, functional integration of universities, quality assurance, etc.)
- CARDS (Community Assistance for Reconstruction, Development and Stabilisation): EU technical assistance for the implementation of major institutional reforms
- PHARE: pre-accession aid aimed at institution-building and support for the harmonisation of national legislation and practice with EU standards

[6] Science and Technology Policy of the Republic of Croatia, 2006-2010
[7] http://public.mzos.hr/Default.aspx?sec=2457

- Sixth Framework Programme: multilateral research projects aimed at the integration of research activities in Europe, the strengthening of the European Research Area and a better use of existing research capacities
- EUREKA: industry-driven research and innovation projects comprising partners from the academia and the private sector
- COST (Cooperation in Science and Technology): cooperation on projects of mutual interests aimed at creating common European standards
- INTERREG: multilateral projects aimed at economic and social development of neighbouring countries and regions
- YOUTH: Community programme aim at supporting youth policies in Europe, youth mobility and its active participation in building Europe.

There are several projects in the field of transport that are representative for activities in research in Croatia:

- **ASDEPP (Advanced Ship Design for Pollution Prevention)** (www.mar.ist.utl.pt/asdepp/) is a Tempus project in the field of maritime transport. The Croatian partner is Faculty of Mechanical Engineering and Naval Architecture (FMENA), Department of Naval Engineering and Marine Technology. The main objectives of the project are improving knowledge about modern computational methods for design of environmentally-friendly ships according to the current industry trends; promoting the usage of advanced computational methods, software tools and best practice in shipbuilding and offshore industry; increasing awareness to environmental protection problems of all important factors concerned by ship safety. Through creating and implementing set of 5 optional (elective) courses on the design of safe and environmentally-friendly ships, it is intended to improve and enrich the curricula of the Master of Naval Architecture (MNA) level at Croatian universities.
- **ASATC Phase II project (Eurocontrol, Crocontrol)** with main objective of strengthening aviation safety and adapting air traffic and aviation conditions in the five CARDS countries to those in the rest of Europe in order to provide timely implementation of the Single European Sky. This project is jointly provided by the European Commission, the Joint Aviation Authorities, EUROCONTROL and the five states of the region. The final outcome of the project is to help national CAAs in establishing National Supervisory Authorities and integrating into JAA and EASA as well as fulfilling the Single European Sky requirement. Furthermore, by national ATM institutions implementing the Single European Sky, safer and more unified system will be created.
- **MOMENTUM (*Multidisciplinary Research and Training on Composite Materials Applications in Transport Modes*)** (www.compositesintransport.com/about.htm). The Croatian partner is Faculty of Mechanical Engineering and Naval Architecture (FMENA). This is a Marie Curie Research Training Network funded by the Human Resources and Mobility

Programme as part of the European Commission FP6. It is an effective and sustainable research platform for the study and development of innovative composite materials applications for the rail, aerospace, maritime and automotive transport modes. This is being done by using outstanding training based on a multidisciplinary approach and transfer of knowledge producing a new generation of researchers with unique skills. *The project* focuses in critical aspects identified as the key future research areas for composites in transport. *The consortium is* formed by 14 organisations of renowned international stature in 11 countries across Europe - academic institutions as well as key members from the aerospace industry (EADS), rail (Alstom), automotive (Centre Ricerche Fiat) and maritime (VT Halmatic).

Furthermore, during 2008, project PHARE 2006 “Restructuring and Development of Croatian Railway system within the framework of EU legislation“ financed by the EU has been initiated, having as a main goal preparation of RC for fulfilling EU membership accessing conditions considering the adjustment of legal and institutional framework within railway sector, in accordance with acquis communautaire. The project has been started in 2009 and is to last until the end of 2010. The total value of the project is 2.2 million Euros, divided into main project and four subprojects of technical support. Croatian railways take part in CARDS program jointly with the other countries in the region through the Study on the regional infrastructure in Balkans, but are not directly involved in the CARDS help program

Since June 2000, Croatia has participated in the European RTD programme *EUREKA* as a full member. Today, there are 27 running technology projects with a total value of €43.7 million, of which Croatian partners contribute €12.2 million. The MSES co finances EUREKA projects with up to 50% of Croatian participation, or at most €150,000 per project, and the rest comes from the partner’s side. On an annual basis, the MSES invest €350,000 in EUREKA projects. Although a small investment, it proved to be very efficient due to the fact that EUREKA has strong partners, international recognition, high standard of international evaluation of projects, and flexible administration. First results after 5 years of participation show that return on investment in EUREKA projects is 4:1 with a good ratio of industry-academia participation.

4. SWOT analysis of the Transport research capacity in Croatia

Strengths	Weaknesses
• favourable strategic position of Croatia in South Eastern Europe • successful development of new scientific instrument aimed at commercialisation of research (role of MSES) • rapid involvement of Croatian research sector into the different instruments of EU financing and increasing awareness of necessity to do so • strong basis in fundamental engineering sciences • long and successful tradition in naval architecture and shipbuilding • vast experience in production of rail vehicles • significantly improved road infrastructure (highways) • Croatia as a EU candidate country has particular opportunities to participate in the FP7 programs	• lack of sufficient number of experienced professionals/experts • existing societal system of values • high regulatory barriers for investments making the climate unfavourable • investing into R&D not appreciated enough as a vital part of the business • although there are numerous formal acts, the real strategic focus in implementation is missing • interest group opposition and lack of transparency • negative attitude towards activities in the cross-sector cooperation • target community not developed enough (industrial sector neglected and/or technologically lagging behind competition and/or unaware of R&D importance and/or financially exhausted) • low level of innovativeness • small productivity of Croatian research community (measured by the number of high quality research papers)
Opportunities	**Threats**
• research in the field of advanced materials applied in transport (e.g. composites, metal foams, new aluminium alloys) • research in the field of advanced and special naval structures • new power systems, engines and fuels • development of aeronautical sector (e.g. general aviation) through offset programs and associated research • research on the subject of higher impact of sustainable transport development	• global economic crisis • high dependence on one economical branch (tourism) endangered by the global climate changes • fluctuations of global fossil fuels prices • very long period to refund invested money into transport infrastructure (increase of public debt) • necessary significant decrease of governmental support in shipbuilding (as required by EC in the accession negotiations) • necessity to invest large sums of money into development of aeronautical sector (only through governmental support)

4.1 Strengths

RC has a very favourable geostrategic position being Central European and Mediterranean country on the crossroads of air and surface paths to Southern, Eastern and Central Europe. Thus, this position opens a lot of opportunities for development of transport sector in general, for investment into infrastructure, development and implementation of new modes of transport, improvement of intermodality etc. The inclination to tourism, on the other side, makes room for improvement of those transport areas that are of importance for development of tourism – e.g. various modes of transport

at and over the sea. The good example is the development of activities including seaplanes, something that is totally neglected in Croatia.

In the recent period, Croatia has been integrated into the European research area through many instruments. This is the case in almost every research area, including transport. However, the success rate of Croatian research institutions at FP calls is not very high, what is not Croatian specificity but more common to all Eastern and South Eastern European countries. In addition, even the most experienced European research communities show dissatisfaction with FP projects success rate. The problem is even more evident if it is taken into account that the preparation of the project itself takes a lot of time, with very uncertain outcome, that way occupying the intellectual capacity of number of capable researchers.

The long tradition of technical universities (e.g. High Technical School in Zagreb has been established in 1919.) still gives excellent basis in the applied fundamental areas of engineering and technology. Therefore, graduates of technical faculties at Croatian universities have excellent knowledge in the basic sciences and mathematics. However, the lack of sufficiently equipped and modernised laboratories makes the final outcome not that successful, as students lack touch with the state-of-the art technology, to some extent due to not enough modernised Croatian industry.

Croatian shipbuilding sector has a very long and rich history and in one period the largest merchant ships in the world (*Berge* class tankers) have been designed and manufactured in the Uljanik Shipyard. Therefore, highly skilled workforce, experienced engineers and highly competent university staff coupled with shipyard's infrastructure, create excellent climate for future research and development in this field.

In the recent years, some very prospective projects in the area of rail transport, such as low floor tram have been designed and produced in Croatia. In addition, Croatian production and maintenance sector in this field is very competent due to the design and maintenance of electric locomotives and various types or railway cars. At the moment, very prospective project of new type of low floor suburban train is under development, what opens new areas of research in this area. This has been recognized by the Croatian government as well, and as illustration, in the year 2008 the Government has planned:

- the opening of tender for procurement of 24 new passenger coaches type Z for speeds up to 230 km/h
- opening of tender for new 18 electrical trains for urban/suburban transport

In the year 2007 major contracts signed in the field of modernization of railways are:

- contract with "Gredelj -TŽV" Factory for Railway Coaches for major upgrade and maintenance of 10 diesel-hydraulic locomotives (value of the contract 62.8 million HRK)
- contract with "Končar – Electrical Vehicles" concerning middle repair and upgrade of 10 electrical locomotive (contract value: 98.2 million HRK)

In addition, in 2008 very lucrative contracts worth 13 million Euros have been signed with foreign customers and "Gredelj – TŽV"[8].

The recently built road infrastructure (highways first and foremost) leaves a lot of room for research in the field of improvement of safety and thorough research of environmental effects of this infrastructure. Furthermore, the interaction of new types of future vehicles and engines with current infrastructure makes it a very promising research area.

Croatia, as a candidate country, is at the moment in a special position, as in the calls and validation of proposed projects, the involvement of institutions or SMEs from candidate countries is one of the requirements. Therefore, the research facilities with good infrastructure and human potential are in a favourable position regarding collaboration within these projects. However, Croatia should use pre-accession period to improve its research sector as more as possible, as this favourable position will be lost once Croatia is the full member of EU. After that, Croatia will compete on the same grants and with the same status as other EU countries, whose strong research infrastructure has already been made coherent with requirements of global competition.

4.2 Weaknesses

There are only 8% of the population with the university degree, of which even smaller number is the field of technical sciences and even less connected with transport. Thus, any serious progress in the R&D in the field of transport will be faced with the shortage of competent researchers. In addition, the number or research assistants (doctoral students), who are the core of the research process, is not sufficient. The period between contract announcements and actual employment is too long, and therefore it is difficult to keep prospective research assistants interested in research position, as industry is usually offering them jobs that are immediately available and with much better salaries.

In the last 15 years, many sociological processes have occurred in Croatia, that are influencing young generations with somehow distorted view towards work discipline and work ethics. The whole climate in the society that surrounds them is not very favourable to scientific work and the impact that science should have in the society. Therefore, it is more and more difficult to convince young people to pursue carrier in science.

The over bureaucratic society makes any investments rather complicated and connected with significant amount of paperwork. This also makes transformation from scientific research to application rather complex and time consuming. On the other side, most of the companies, facing serious struggle to survive, do not recognize investments into research as part of their vital, natural part of business. As the investments in science are long term activity without firm guarantee for success, they approach research institutions

[8] www.tzv-gredelj.biz.hr/eng/

(e.g. universities) mostly in situations when particular problem is imminent. This kind of work is mostly unacceptable for research institutions, because scientific outcome of these activities is negligible, and their intention is aimed at long term research projects.

Although there are numerous formal documents developed at many levels, the real implementation of these plans and strategies is slow and sometimes inefficient. This is particularly important when restructuring of certain sectors is required, what is considered politically very sensitive. Furthermore, interest groups through their lobbying and thanks to lack of transparency, additionally slow down this process. Of particular importance is the fact that surface transport infrastructure is not uniformly developed in various parts of Croatia, what implies the necessity to further invest into transport infrastructure. Finally, the country is not trying enough to use transport activities in the increase of the overall economic activities. There are some estimations that fixed costs of Croatian transport organisations are 20 – 50% higher than in the neighbouring countries, regardless if they are EU members or not. Therefore, it would be viable to perform the comparative analysis and find the means of diminishing these in our economical conditions.

In the transport sector research, one of the crucial problems is the lack of technologically advanced and competitive industry. Even in shipbuilding, that is one of the most important transport productive sectors, the technological lagging behind the competition is evident in most of the production facilities. In some other sectors, such as rail vehicles production, there are some technologically advanced projects, but their commercial efforts (particularly export outcome) are not of the sufficient magnitude to create the boost for the whole sectors. Coupled with financially drained companies, it is clear that research is not one of their priorities.

In the year 2004, the gross domestic product *per capita* was measured as standard purchasing power, and it amounted to 45.6% of the average EU GDP. The level of innovativeness is ten times lower than in EU countries, and technological lag and unsatisfactory work productivity are discernible. In addition, based on the number of internationally referenced papers, Croatia is low on the scale of developed and medium developed countries, which implies a necessity to improve the quality of this sector as well. Investments into science, research and technological development, which amounted to 1.25% of GDP in 2004 are inadequate both in their scope and structure, and therefore do not enable progressive movements, but rather only maintain the existing, relatively inefficient status.

Although Croatia has invested heavily into the building of new highways in the last 10 years, the current condition of transport in Croatia is far from satisfactory, especially in harbours, maritime and inland navigation and railways. One of the reasons for this is partially in the events in this area – war activities, inherited problems as well as not adequately defined development strategy. The contribution of intermodal transport is rather low what leaves a lot of room for improvement and investment.

In the maritime and inland navigation, political and economical changes in the countries of the Central / East Europe that were inclined to the Croatian harbours, had as a consequence significant negative gradient of quantity of goods and passengers, with particularly devastating effect in the line shipping.

4.3 Opportunities

Despite all the weaknesses, the Government has recognized the importance of using research in societal development and thus encourages particular Ministries to develop their specific activities and plans to serve this purpose. As an example, the MSES identifies and supports efforts of the research community to participate in research in the areas of transport, both on national level (jointly with other relevant Ministries) and international level, e.g. *7th Framework Programmes*, endorsed to support the formulation and implementation of Community policies.

The continuation of work in the special ships and vessels is very promising as this is a very mature sector with long tradition and qualified workforce. The Department of Naval Engineering and Marine Technology at University of Zagreb (30 researchers), Department of Naval Engineering and Ocean Engineering (11 researchers), University of Rijeka, Department of Mechanical Engineering and Naval Architecture (5 researchers) University of Split have very experienced researchers who are well connected with industry. Therefore, it is natural to expect that they would be leaders in defining new technologies and research areas of interest to Croatian shipbuilding industry. Particularly promising is the design of small ships, as well as research in the area of new types of propulsion including new fuels. Naturally this can't be performed without new scientific and engineering methodology in stress analysis, optimisation and application of new generation of engineering materials (e.g. composites engineering and sandwich materials). Connected with this is the area of ballast waters management and ecological aspects of ship design as one of the top priorities in closed seas such as Adriatic Sea.

Although there is no aeronautical industry in Croatia, there is a small but capable group of researchers at Department of Aeronautical Engineering at FMENA. They have several research and technological projects connected mainly with Croatia Airlines and their technological needs. As aeronautical engineering is everywhere in the world the most technologically advanced, including various disciplines of aeronautics, mechanical and electrical engineering, it is always the indicator of technological ability of the country. Therefore, in order to keep up with the technologically advanced communities, it would be necessary to start development of aeronautical engineering sector in Croatia. This can be through the small offset or as second and third tier producer for large airframe producers. The particularly interesting field can be Small and General Aviation, where good links could be established with corresponding producers in East European countries.

Research in the advanced materials engineering is of particular interest for Croatia. This includes several areas: production and characterisation of advanced materials and analysis of advanced structures, particularly using numerical methods (e.g. finite elements method). First and foremost, this includes advanced composites, MMC, GLARE, metal foams and new generation of aluminium alloys (e.g. aluminium- lithium alloys very frequently used in aeronautics). This is a very prospective field, as it can include a research in substituting existing structures with advanced ones. In addition, there is a vast area of advanced ships where new materials are of particular importance. This research would immensely improve the competitiveness of Croatian industry in the world market and at the same time would dramatically increase the scientific output within Croatian research institutions.

New power technologies, engines and fuels are the area when Croatia could significantly contribute to European research community. There are already projects dealing with use of biofuels, hydrogen, fuel cells and electric engines, but mostly only at theoretical level. However, this provides excellent basis for collaboration with interested partners, and in the whole area of maritime and inland navigations vessels there is a large potential for the implementation of research results. Closely connected to this is the research on the ecological aspects of new transport technologies, assessed through the whole life-cycle: from the first *kw* produced to the last *kg* recycled, where the cost is the dominant parameter.

There is a vast field that covers almost all means of transport in Croatia and includes organisation, logistics and management in transport. Of the most important is the research in the field of intermodal transport, including integration of Croatian transport into the European transport areas, as intermodality is one of the priorities within European transport research area. This includes also modelling of various transport processes, such as control and prediction of future transport expansion especially in urban areas. Closely connected to this is the area of implementation of information-communication technologies in intelligent transport systems. The area of security and safety of means of transport is also very promising area of research due to many globally present threats.

4.4 Threats

The global economic crisis is without any doubt the most serious threat that all parts of Croatian society are experiencing with very uncertain forecasts on its duration and outcome. It is very difficult to predict the magnitude of the influence on the research sector, including the transport. On the other hand, it is difficult to diversify how much the economical problems in Croatia are the result of global crisis, and how much is it the result of internal errors in economical strategy at state level during the long period.

In Croatia, development of transport sector is highly dependent on tourism as a lot of activities in surface and maritime transport are directly connected with these activities. However, tourism is a very vulnerable economic activity, and exceptionally dependent on the natural resources and global climate activities. Transport and tourism are especially interconnected when environment interactions are taken into account, especially in the closed sea such as Adriatic. On one side tourism requires strong transport sector, but on the other side the ecological threats are increasing. The global climate changes are also one of the factors to be considered very seriously, as it is forecasted that Mediterranean area will be particularly seriously hit. Furthermore, large investments into the industrial development are the precursor to the economic viability of the high investment in transport. There is a high proportion of these investments based on the government loans what makes the country even more vulnerable to the global economic crisis ahead. With a drop of GDP between 1% and 3% forecasted for 2009, the decrease of industrial production is imminent what makes investment into research even more difficult.

It is obvious that the shipbuilding sector is late in the necessary technological and economical reforms and the whole sector is threatened by the EC conditions that high governmental subsidizing of the industry will not be allowed. Thus, it is not clear if there will be enough economical power to perform the necessary restructuring of the shipbuilding sector and make it more high-tech, and thus more globally competitive, where new R&D activities would be of vital importance.

In the air transport, the key is the fluctuation of crude oil prices on the world market, as fuel contributes largely to the costs of the airline companies. Therefore, the integration of national flag company, Croatia Airlines into the Star Alliance has been crucial for their survival in the global market. The absence of any significant production in this sector is noticeable, but this demands state investment and clear vision of technological development in this sector, something that is totally missing. Any competitive manufacturing in the aeronautical sector requires large investments, clear business policy and strong governmental support – something that is clearly missing in the Croatian governmental bodies. Within majority of countries with aeronautical sector, production is tightly connected with the activities in the military sector, and in most cases, the start of the manufacturing in aeronautical programs is tightly connected with offset programs of various complexity. However, at the moment, there is no serious planning of offset programs in this field, although there are a lot of discussions on the new procurements within the Croatian Air Force.

Number of researchers and investment in research is constantly decreasing. Without the increase of the number of high quality researchers, it is highly unlikely that the research sector will have enough manpower for the required research tasks. Based on the available references, it is clear that the expenditures in research and development are

steadily decreasing (in nominal value), what is even more noticeable if rate of inflation is taken into account. Similar trend is visible in the number of published scientific papers. Although there are significant structural activities performed within MSES and HIT (CTI), it is difficult to assess what is imminent financial benefit of these investments, and what is the return of the invested money. With the current fiscal debt in Croatia, the long period required for invested research money to produce revenue, makes the whole process of investment into research even more sensitive and prone to budget cuts.

The fluctuations of fossil fuel prices on global market make the whole transport sector very vulnerable and sensitive to very serious reduction in number of passengers or quantity of goods. This process is not relieved with the fossil fuel and gas being used as the weapon of political pressure in the search for global domination.

5. Transport research priorities for Croatia

5.1 Transport research priorities on the basis of the country's readiness

1. Ecological aspects of transport (e.g. noise, pollution) - Environmentally Sustainable Transport
2. Safety of maritime structures regarding ecological aspects
3. Advanced materials and structures engineering in the means of transport
4. Ballast waters management in closed seas
5. Intermodal transport and harmonization of various modes of transport with final goal of full integration into European transport area
6. Traffic control, security and safety in urban areas
7. Advanced design methodology in the development of new means of transport
8. Integration of maritime and inland harbours
9. Shipbuilding for inland waterways
10. Information-communication technologies in intelligent transport systems
11. Acquis Communautaire in transport
12. Research on increasing efficiency and reliability of maritime and inland navigation

5.2 Transport research priorities on the basis of future potential

1. Research on new types of fuels (e.g. hydrogen or bio-fuels) in various means of transport

2. Advancement of aeronautical research in modelling of structural response
3. Advanced simulations of mechanical behaviour of means of transport
4. Development of new types of city transport
5. Application of distant learning technologies in various fields of transport technologies
6. The Croatian involvement and assessing to Galileo (future European global positioning system) with transport applications
7. Research on telematic applications for freight and passenger traffic and absorption in the European telematic system
8. Electronics and microprocessors in means of transport

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Annex I. Classification of the Transport research fields (Frascati Manual, 2002, OECD)

Table 3.1. **International Standard Industrial Classification arranged for the purposes of R&D statistics** *(cont.)*

	ISIC Rev. 3.1 Division/Group/Class	NACE Rev. I.1 Division/Group/Class
Insulated wire and cable (includes optic fibre cables)	*313*	*31.3*
Accumulators, primary cells and primary batteries	*314*	*31.4*
Electric lamps and lighting equipment	*315*	*31.5*
Other electrical equipment n.e.c.	*319*	*31.6*
Radio, television and communication equipment and apparatus	32	32
Electronic valves, tubes and components	*321*	32.1
TV, radio transmitters and line apparatus	*322*	32.2
TV and radio receivers, sound and video goods	*323*	32.3
Medical, precision and optical instruments, watches and clocks (instruments)	33	33
Medical appliances, instruments and control equipment	*331*	*33.1*
Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	*3312*	*33.2*
Industrial process control equipment	*3313*	*33.3*
Optical instruments and photographic equipment	*332*	*33.4*
Watches and clocks	*333*	*33.5*
Motor vehicles, trailers and semi-trailers	34	34
Other transport equipment	35	35
Ships and boats	*351*	*35.1*
Railway and tramway locomotives and rolling stock	*352*	*35.2*
Aircraft and spacecraft	*353*	*35.3*
Transport equipment, n.e.c.	*359*	*35.4 + 35.5*
Furniture; other manufacturing, n.e.c.	**36**	**36**
Furniture	361	36.1
Other manufacturing, n.e.c	369	36.2-36.5
Recycling	**37**	**37**
ELECTRICITY, GAS AND WATER SUPPLY	**40, 41**	**40, 41**
CONSTRUCTION	**45**	**45**
SERVICES SECTOR	**50-99**	**50-99**
Wholesale, retail trade and motor vehicle repair	**50, 51, 52**	**50, 51, 52**
Wholesale of computers, computer peripheral equipment and software	*5151*	*51.84*
Wholesale of electronic parts and equipment	*5152*	*51.86*
Hotels and restaurants	**55**	**55**
Transport, storage and communications	**60, 61, 62, 63, 64**	**60, 61, 62, 63, 64**
Telecommunications	642	64.2
Other	60-64 less 642	60-64 less 64.2
Financial intermediation (includes insurance)	**65, 66, 67**	**65, 66, 67**

Table 3.2. **Fields of science and technology**

1.	**NATURAL SCIENCES**
1.1.	Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]
1.2.	Physical sciences (astronomy and space sciences, physics, other allied subjects)
1.3.	Chemical sciences (chemistry, other allied subjects)
1.4.	Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)
1.5.	Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)
2.	**ENGINEERING AND TECHNOLOGY**
2.1.	Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)
2.1.	Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]
2.3.	Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, *e.g.* systems analysis, metallurgy, mining, textile technology and other allied subjects)
3.	**MEDICAL SCIENCES**
3.1.	Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)
3.2.	Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)
3.3.	Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)
4.	**AGRICULTURAL SCIENCES**
4.1.	Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)
4.2.	Veterinary medicine
5.	**SOCIAL SCIENCES**
5.1.	Psychology
5.2.	Economics
5.3.	Educational sciences (education and training and other allied subjects)
5.4.	Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary, methodological and historical S&T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences]
6.	**HUMANITIES**
6.1.	History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)
6.2.	Languages and literature (ancient and modern)
6.3.	Other humanities [philosophy (including the history of science and technology), arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S&T activities relating to the subjects in this group]

Source: OECD.